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Potting media, growth and build-up of nutrients in container-grown desert rose

Ronan Carlos Colombo, Vanessa Favetta, Thadeu Rodrigues de Melo, Ricardo Tadeu de Faria, Marcelo Augusto de Aguiar e Silva.

Department of Agronomy, State University of Londrina, Caixa Postal 6001, 86051-990, Londrina, PR, Brazil

***Corresponding author: ronancolombo@yahoo.com.br**

Abstract

The commercial and ornamental value of the desert rose (*Adenium obesum*) is mainly related to the development of the caudex, which is influenced by the nutritional state of the plant, among other factors. However, little is known about the nutritional requirements of this species and studies are at an early stage. Therefore, the aim of this study was to investigate the influence of potting media on the growth and nutrient build-up in desert rose. Plants were grown in the greenhouse in the following potting media: sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML). The pots, each containing one plant, were arranged in a fully randomized design with five replications per treatment. The following parameters were evaluated at 210 days: shoot height; caudex diameter at the base; leaf, stem and root fresh and dry weight; root system volume and build-up of macro and micronutrients in the roots, stems and leaves by chemical analysis of these organs. The plants grown in S+CF and V+CF mixes exhibited higher growth rates than the other plants and greater nutrients build-up in dry matter. A high quantity of manganese (Mn) was absorbed by the plants grown in the above-mentioned mixes; however, it cannot be affirmed that this element had a direct effect on the absorption of the other micronutrients. Therefore, the S+CF and V+CF mixes showed the highest increments for desert rose caudex growth and is recommended for cultivating this species.

Keywords: *Adenium obesum*, Mineral nutrition, Growth medium, Substrates, Apocynaceae.

Abbreviations: EC_electrical conductivity; S+CF_sand + Amafibra® 47 coconut fiber; S+L_sand + Lupa®; S+ML_sand + modified Lupa®; V+CF_vermiculite + Amafibra® 47 coconut fiber; V+L_vermiculite + Lupa®; V+ML_vermiculite + modified Lupa®; WRC_water retention capacity.

Introduction

The desert rose, *Adenium obesum* (Forssk.), Roem. & Schult., is found in the sub-Saharan Africa, from Sudan to Kenya and from Western Senegal to the South of Natal and Swaziland (McLaughlin and Garofalo, 2002). Over the last decades, the plant has been disseminated in Brazil due to its similarity to plants of the genus *Pachypodium* spp., belonging to the same botanical family as the desert rose (*Apocynaceae)*. The species is caudiciform and develops swollen stems and/or roots that serve as primary organs for storing water. The flowers have five sepals and five petals in various shades, emerging from a floral tube (Dimmitt et al., 2009). Despite the enormous diversity of its flowers, the most appealing feature of this plant is the development of the caudex, which can be affected by the potting medium and by how it influences the absorption and build-up of nutrients by the plant. Plants grown in pots are characterized by a particularly high (and unbalanced) ratio between the aerial part and the root, and by much higher water, air and nutrient requirements than those grown in the soil (and in the open field), where growth rates are slower and the volume of soil available for the roots is theoretically unlimited (Gruda, 2012). Various kinds of potting media are used for producing ornamental plants in containers. However, to obtain satisfactory results, it is essential to characterize the physical and chemical properties of the materials (Abreu et al., 2002; Pacheco, 2007). Physical, chemical and biological substrate properties can change and deteriorate with time and use, which may affect both crop management and behavior. Mechanical degradation of substrates can alter the pore structure, which may in turn affect retention and movement of nutrient solution and root aeration (Orozco and Marfà, 1995; Giuffrida et al., 2007; Verhagen, 2009). Air/water relationship of a potting medium (substrate) depends on its physical properties, and mainly on the density and porosity of each material (Verdonck, 1983; Kämpf, 2000b; Santos et al., 2002). In terms of chemical properties, the pH and electrical conductivity (EC) of the material or mix are extremely important (Kämpf, 2000a).The pH of the potting medium solution is linked to the availability of nutrients to the plant. The recommended pH for potting media containing predominantly organic matter is between 5.0 and 5.8 (Kämpf, 2000b). Among the scarce literature available on mineral nutrition in the desert rose, the work of McBride et al. (2014) is worthy of note since it evaluates the effect of light intensity and nitrogen levels on the growth and flowering of two cultivars of *A. obesum*. However, the authors do stress the need for further studies. Therefore, the aim of this study was to investigate the influence of potting media on the growth and build-up of nutrients in desert rose plants.

Results and Discussion

Potting media and plants growth

Since potted plants have restricted volume in which the roots can grow, the choice of a potting medium has a direct effect on plant growth, mainly due to the physical and chemical characteristics of each material used. Physical analysis of the mixes used in this experiment (Table 1) showed that the vermiculite + coconut fiber (V+CF) mix had the lowest density (136 g L^{-1}) and highest water retention capacity (528 mL L^{-1}). It is therefore probable that these two characteristics directly affected plant growth in this medium, as shown in Table 2. According to Kämpf (2000a), it is more difficult to grow plants in potting media of higher density, with recommended dry densities ranging from 200 to 400 g L^{-1} for pots with a column of potting medium up to 15 cm deep, as shown in this study (12 cm). However, despite having densities between 200 and 400 g L^{-1}, the vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML) mixes performed statistically less well than the V+CF mix in terms of the assessed phytometric parameters, suggesting that density is not a plant growth limiting factor (Table 2). For the sand + coconut fiber (S+CF) mix, caudex diameter, root system volume and dry weight of stems and roots exhibited averages that were statistically the same as those for the V+CF mix (Table 2). The increments in these parameters are attributed to the characteristics of the coconut fiber, such as high stable physical structure, high CEC, high total porosity (95.1 to 96.3 % of volume), aeration capacity (46.1 to 48 % of volume) and excellent available water retention capacity (19.2 to 20 % of volume) (Malvestiti, 2011).

Table 1 shows the chemical properties of the potting media based on pH and electrical conductivity (EC). Since these properties vary from one material to another, nutrient availability to the plants can be specified as a function of these properties, especially pH (Kämpf, 2000a). The electrical conductivity of mixes containing vermiculite was lower than those containing sand, indicating translocation of ions in the solution to the exchange complex. Plant production systems with excessive irrigation are subject to leaching of the substrate solution, and this can be extremely important in providing higher nutrient availability to the plants. However, there was no leaching in the experiment since potting media moisture content did not exceed the WRC. In terms of WRC (Table 1), values measured for all mixes were close to those considered ideal, ranging from 40 to 50% of the substrate volume (Verdonck et al., 1981). But despite the fact that water volumes retained by the mixes were close, it is likely that the volume of water available to the plants varied from one mix to another.

Plants growth and build-up of nutrients

At 210 days after the experiment was set up, a further measurement of potting medium pH and EC was taken (Table 3). The pH values of the S+CF and V+CF mixes were more acid than the other media, at 4.05 and 4.50 respectively. However, the initial pH values of the potting media were high (Table 1) and the drop in pH was related to the absorption of cations by the plants (Fig 1) as a result of the electrogenic pump H^+ATPase activity (Yi-Yong et al., 2011). Potting media with a variety of physical and chemical properties are used to grow desert rose (McLaughlin and Garofalo, 2002; Dimmitt et al., 2009; McBride, 2012; McBride et al., 2014). However, our study shows that a mix of vermiculite + coconut fiber (V+CF) produced the best results for container-grown plants (Table 2). Aerial part height showed the greatest increment in the V+CF mix, but differed statistically only from the V+L and V+ML mixes. In addition, the mix did not influence leaf fresh weight, as well as the build-up of P, Ca, Zn and Fe in the leaves (Table 4).

In terms of caudex diameter, root system volume and fresh and dry weight of stems and roots (Table 2), the highest averages were observed in the S+CF and V+CF mixes. It seems that the highest desert rose growth rate in these potting media is related to its capacity to provide plants with manganese (Mn), implying that the other potting media were relatively poor in this nutrient for the species in question, since the contents of other nutrients in the potting media differed only slightly (Table 4). Table 5 shows the correlation between nutrient build-up and the increment in dry matter. The best correlation was observed for Mn, indicating that Mn influences the increment in the growth parameters evaluated. In terms of nutrient concentration in dry matter, there was a significant negative correlation for nitrogen (N) and calcium (Ca) (Table 5). This was due to the dilution of nutrients that occurs when the plant synthesizes carbon compounds by means of photosynthesis. Negative correlations could therefore indicate that these nutrients were limiting plant growth, after the stimulus provided by the supply of Mn. However, it is likely that during plant growth the supply of N and Ca was not sufficient to maintain carbon fixation rates.

In mixes based on composted pine bark, pH values tend towards neutral. This could have restricted the availability of nutrients in the substrate solution and nutrient absorption by the roots. However, high nutrient levels were found in the root, stem and leaf dry matter of the plants grown in these mixes (Table 4). On the other hand, the build-up of dry matter in these plants was lower than in plants grown in the S+CF and V+CF mixes. This implies that the higher concentration of nutrients per kilogram of dry matter in mixes based on composted pine bark does not lead to higher growth.

In terms of nutrient build-up in each plant, dry matter results in Table 6 indicate that plants grown in the V+CF mix showed higher quantities of nutrients. We can therefore infer that, although the desert rose grows in regions with poor soil, from a nutritional point of view, plant growth is influenced by the level of nutrients absorbed. The build-up of N was statistically the same in all plants, irrespective of the potting medium. However, the values of N in dry matter were lower that the values found by McBride (2012), as well as the values of Ca, magnesium (Mg) and iron (Fe). In contrast, concentrations of phosphorus (P), potassium (K) and Mn were higher than the values found by McBride and used as references. In terms of the build-up of P and K per plant, we observed high levels in plants grown in the S+CF and V+CF mixes. Bunt (1988) suggested that, for organic potting media, the higher absorption of phosphorus occurs at a pH below 5, which is in line with the pH range found for these two potting media. On the other hand, Mercurio (2002) reported that K is more available to plants at pH values between 6 and 8. However, in all the potting media studied, with the pH ranging from 4.05 to 7.25, high quantities of this nutrient were made available to the plants. Furthermore, we know that K is the macronutrient most absorbed by desert rose plants, followed by N and Ca. Boron (B) and copper (Cu) were not detected during plant tissues analysis, and iron was not detected in the roots and stems. This highlights the importance of further studies on mineral nutrition in the desert rose, since there are many gaps in our knowledge of the nutritional requirements of this plant and its responses to fertilizers. Special emphasis should be placed on Mn, with

Table 1. Physical and chemical characterization of potting media: sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML).

[z]Substrate	[z]DS (g L^{-1})	WRC (mL L^{-1})	pH	EC (mS cm^{-1})
S+CF	838.00	497.33	5.83	2.37
V+CF	136.67	528.00	6.11	0.79
S+ML	1.018.67	428.67	6.81	0.86
V+ML	273.33	486.00	6.66	0.41
S+L	1.042.00	460.67	7.36	1.06
V+L	337.33	510.67	7.07	0.41

[z]DS: potting medium density; WRC: water retention capacity; EC: electrical conductivity.

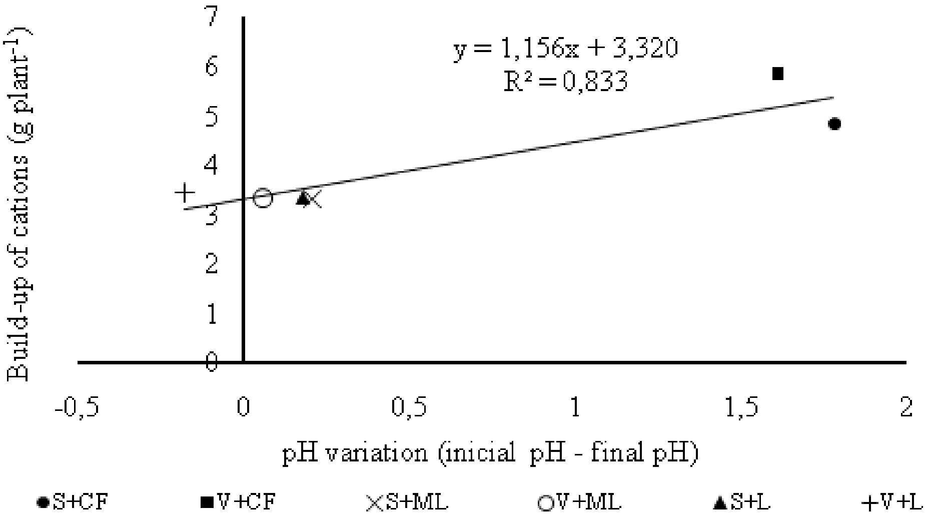

Fig 1. Total absorption of cations (calcium, magnesium, potassium, manganese, zinc and iron) at 210 days by *Adenium obesum* plants and variation of pH (initial – final) of the following potting media: sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML).

the apparent demand higher that the amount supplied by the majority of potting media used.

Materials and Methods

Experimental site

The experiment was conducted between December 2013 and July 2014 in a Van der Hoeven® climatized greenhouse, covered with polycarbonate sheets and with a humid cool control system, switched on when the inside temperature reached 28 ºC and switched off at 26 ºC. The greenhouse is located in the Agronomics Department of the Londrina State University (UEL).

Plant material

Seedlings of *Adenium obesum* (Forssk.), Roem. & Schult. were grown from seed in 50 mL plastic recipients, filled with a 1:1 (v/v) mix of Lupa® + and composted bird litter. Plants were kept in an agricultural greenhouse covered with a film of transparent polyethylene and black plastic screening (Sombrite®) with 50% light retention. Nine months after sowing, seedlings were selected to obtain a homogeneous batch, with the following average parameters: stem height (11.9 cm ± 1.1), caudex diameter (27.9 mm ± 2.5) and plant fresh weight (37.3 g ± 6.3). Plants were marked with a reference number and the increments in these characteristics were evaluated at the end of the experiment.

Treatments and experimental design

To set up the experiment, 3 L black polyethylene pots were used and filled with the respective potting media: sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML). Sand and vermiculite were of average grain size (0.2-0.6 mm and 0.50-1.19 mm, respectively). The modified Lupa® potting medium consisted of a mix of 70% Lupa® potting medium + 30% shredded pine bark, with an average grain size of 7 mm, and all potting media were mixed in a proportion of 1:1 (v/v) of the respective materials. The pots, each containing one plant, were arranged in a completely randomized design with five replications per treatment.

Potting media physical analysis

Mixes used as potting media were analyzed to determine their physical characteristics: dry density (g L^{-1}) and water

Table 2. Phytometric parameters evaluated at 210 days in potted *Adenium obesum* in six potting media.

^{z}Substrate	Aerial part height (cm)	Caudex diameter (mm)	^{ns}Leaves fresh weight (g)	Stems fresh weight (g)
S+CF	^{y}36.10 ab	60.94 ab	39.77	215.42 ab
V+CF	43.80 a	67.41 a	45.57	250.30 a
S+ML	37.00 ab	55.01 bc	33.44	165.39 bc
V+ML	28.80 b	51.47 bc	36.04	153.67 c
S+L	35.64 ab	48.38 c	35.57	144.64 c
V+L	30.70 b	56.42 bc	37.98	167.61 bc
CV (%)	17.54	8.72	17.29	17.21

Substrate	Roots fresh weight (g)	Roots volume (mL)	Leaves dry weight (g)	Stems dry weight (g)
S+CF	207.56 ab	207.00 ab	4.38 ab	20.65 ab
V+CF	274.37 a	274.00 a	6.14 a	26.17 a
S+ML	173.62 bc	173.00 bc	4.14 b	15.44 b
V+ML	159.31 bc	160.00 bc	4.38 ab	14.27 b
S+L	129.44 c	130.40 c	4.03 b	13.29 b
V+L	154.38 bc	155.00 bc	4.49 ab	16.39 b
CV (%)	21.59	21.04	20.08	22.2

Substrate	Roots dry weight (g)	Aerial part height increment (cm)	Caudex diameter increment (mm)	Plant fresh weight increment (g)
S+CF	16.35 ab	23.90 ab	33.50 ab	427.13 b
V+CF	20.70 a	30.78 a	38.34 a	534.82 a
S+ML	11.54 bc	24.44 ab	26.28 bc	331.49 bc
V+ML	11.51 bc	17.26 b	21.59 c	305.16 c
S+L	8.96 c	22.46 ab	21.29 c	270.95 c
V+L	11.73 bc	18.14 b	30.20 abc	324.86 bc
CV (%)	25.75	25.43	16.15	14.72

^{z}Sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML). ^{y}Separate lower case letters for each variable showed a difference in the Tukey test at 5% probability. ns: differences not significant.

Table 3. pH and electrical conductivity (EC) values taken for six potting media after growing *Adenium obesum* for 210 days.

^{z}Substrate	pH	EC (mS cm^{-1})
S+CF	4.05	0.75
V+CF	4.50	0.71
S+ML	6.60	0.50
V+ML	6.60	0.42
S+L	7.18	0.72
V+L	7.25	0.71

^{z}Sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML).

Table 4. Content of macronutrients nitrogen (N), potassium (K), phosphorus (P), calcium (Ca) and magnesium (Mg), and micronutrients manganese (Mn), zinc (Zn) and iron (Fe) at 210 days in the roots, stems and leaves of *Adenium obesum* grown in pots in six different potting media

Roots								
	----------g kg^{-1}----------					----------mg kg^{-1}----------		
^{z}Substrate	N^{ns}	K	P^{ns}	Ca	Mg^{ns}	Mn	Zn^{ns}	Fe^{nu}
S+CF	6.96	28.34 ab^{y}	2.59	2.63 a	2.22	361.94 a	17.76	-
V+CF	5.38	27.99 ab	2.08	0.88 b	2.87	218.66 b	10.48	-
S+ML	6.8	21.24 b	2.14	2.97 a	2.13	36.66 c	26.67	-
V+ML	8.64	28.47 ab	1.5	1.96 ab	2.47	34.69 c	15.88	-
S+L	8.68	35.33 a	2.03	2.36 ab	1.97	11.66 c	12.01	-
V+L	6.95	29.47 ab	1.72	1.59 ab	2.5	21.58 c	9.84	-
CV (%)	24.36	15.45	31.7	41.41	21.13	40.06	62.8	-
RV^{x}	15-25	16-28	1.3-2.1	3.4-4.6	7.0-9.8	18.0-29.2	21.7-24.0	202-353

Stems								
	----------g kg^{-1}----------					----------mg kg^{-1}----------		
Substrate	N	K^{ns}	P	Ca	Mg	Mn	Zn^{ns}	Fe^{nu}
S+CF	7.83 a	23.48	3.02 a	8.50 ab	2.21 b	288.43 a	20.54	-
V+CF	4.65 b	26.28	2.37 ab	3.49 b	4.32 a	173.55 b	10.67	-
S+ML	7.35 ab	21.03	2.22 ab	12.10 a	2.42 b	18.19 c	27.93	-
V+ML	8.24 a	22.51	1.40 b	9.26 ab	3.24 ab	36.05 c	18.07	-
S+L	8.46 a	28.98	2.02 ab	10.41 a	2.58 b	14.13 c	23.73	-
V+L	7.57 ab	22.95	1.54 b	6.13 ab	3.24 ab	23.66 c	9.14	-
CV (%)	22.01	19.42	35.09	36.73	20.84	35.78	59.95	-
RV	15-21	8.9-13.4	1.0-1.4	8.2-10.6	5.3-7.8	23.2-26.8	25.0-34.5	28.8-36.8

Leaves								
	g kg^{-1}					mg kg^{-1}		
Substrate	N	K	P^{ns}	Ca^{ns}	Mg	Mn	Zn^{ns}	Fe^{ns}
S+CF	18.95 b	30.40 ab	1.70	15.65	2.34 b	850.11 a	15.71	87.73
V+CF	19.08 b	21.52 b	1.46	13.22	8.60 a	1045.21 a	20.91	131.38
S+ML	24.66 ab	24.75 ab	1.65	16.15	2.50 b	173.64 b	42.66	71.33
V+ML	26.42 ab	25.00 ab	1.48	13.67	4.62 b	193.54 b	22.63	99.43
S+L	30.12 a	33.81 a	1.72	12.31	2.17 b	78.47 b	23.03	104.17
V+L	27.08 ab	22.86 ab	1.3	13.89	4.82 b	173.11 b	15.02	92.63
CV (%)	17.79	22.35	19.79	22.99	37.75	59.46	73.94	37.63
RV	19-24	4.5-6.5	0.9-1.2	15-16	8.4-8.8	86.0-117.3	9.3-10.2	35.5-48.2
Total								
	g kg^{-1}					mg kg^{-1}		
Substrate	N	K	P	Ca	Mg	Mn	Zn^{ns}	Fe^{nu}
S+CF	33.75 cd	82.23 ab	7.30 a	26.77 ab	6.77 b	1500.48 a	54.01	-
V+CF	29.12 d	75.79 b	5.91 ab	17.58 b	15.79 a	1437.43 a	42.07	-
S+ML	38.81 bc	67.71 b	6.01 ab	31.23 a	7.05 b	228.49 b	97.26	-
V+ML	43.30 ab	75.98 b	4.37 b	24.89 ab	10.32 b	264.27 b	56.58	-
S+L	47.25 a	98.12 a	5.76 ab	25.09 ab	6.72 b	104.26 b	58.77	-
V+L	41.60 abc	75.27 b	4.56 b	21.60 b	10.55 b	218.35 b	34.01	-
CV (%)	11	12.99	26.39	19.56	20.36	39.39	57.23	-
RV	49-70	29.4-47.9	3.2-4.7	26.6-31.2	20.7-26.4	127-173	56-69	266-438

[z]Sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML). [y]Separate lower case letters for each variable showed a difference in the Tukey test at 5% . ns: differences not significant. nu: nutrient undetected. [x]RV: reference value for each nutrient based on McBride's study (2012).

Table 5. Spearman's correlation for nutrient build-up (g plant^{-1}) and concentration (g kg^{-1} dry matter – DM) with total dry matter of *Adenium obesum*.

Parameters	N	K	P	Ca	Mg	Mn	Fe	Zn
	g plant^{-1}							
Coefficient	0.0394	0.4914**	0.4945**	0.1092	0.4999**	0.6387**	0.2912	0.0274
p-value	0.8362	0.0064	0.0060	0.5641	0.0054	0.0002	0.1185	0.8861
	g kg^{-1} of DM							
Coefficient	-0.7793**	-0.1560	0.0331	-0.5333**	0.3143	0.6601**	-0.0007	-0.2983
p-value	<0.0001	0.4089	0.8620	0.0028	0.0910	0.0001	0.9981	0.1094

* Significant at 5% probability; ** Significant at 1% probability.

Table 6. Build-up of macronutrients nitrogen (N), potassium (K), phosphorus (P), calcium (Ca) and magnesium (Mg) and micronutrients manganese (Mn), zinc (Zn) and iron (Fe) at 210 days in potted *Adenium obesum* plants grown in six potting media.

	g plant^{-1}					mg plant^{-1}		
[z]Substrate	N^{ns}	K	P	Ca	Mg	Mn	Zn^{ns}	Fe
S+CF	1.40	3.39 ab[y]	0.30 a	1.11 a	0.28 bc	61.70 a	2.23	3.61 b
V+CF	1.54	4.01 a	0.31 a	0.93 ab	0.84 a	75.96 a	2.24	6.95 a
S+ML	1.22	2.05 c	0.19 ab	0.97 a	0.27 bc	7.22 b	3.18	2.23 b
V+ML	1.31	2.27 c	0.13 b	0.73 ab	0.30 bc	8.30 b	1.82	3.07 b
S+L	1.22	2.52 bc	0.15 b	0.67 b	0.17 c	2.97 b	1.53	2.83 b
V+L	1.36	2.43 c	0.15 b	0.69 b	0.33 b	7.07 b	1.19	2.97 b
CV (%)	22.18	17.02	31.69	25.41	21.68	43.01	68.53	40.96

[z]Sand + Amafibra® 47 coconut fiber (S+CF), sand + Lupa® (S+L), sand + modified Lupa® (S+ML), vermiculite + Amafibra® 47 coconut fiber (V+CF), vermiculite + Lupa® (V+L) and vermiculite + modified Lupa® (V+ML). [y]Separate lower case letters for each variable showed a difference in the Tukey test at 5% probability. ns: differences not significant.

retention capacity - WRC (mL L-1) and chemical characteristics: pH and electrical conductivity - EC (mS cm^{-1}) (Table 1), according to the method proposed by Kämpf et al. (2006). Based on the WRC of each potting medium, the volume of water for irrigation was calculated to keep potting media between 80 and 90% WRC.

Crop fertilizer

Fertilizer was applied to the plants monthly, except for the first application (45 days after beginning the experiment), using a 06-04-04 (NPK) commercial fertilizer solution plus 0.5% Mg, 1% S, 0.1% Fe, 0.05% Mn, 0.02% B, 0.1% Zn and 0.05% Cu), adding 50 mL of solution to each pot.

Characteristics evaluated

At 210 days, the following phytometric characteristics were evaluated: aerial part height (cm); caudex diameter (mm); fresh and dry weight (g) of leaves, stems and roots; and root system volume (mL) measured using a graduated cylinder containing a known volume of water, inserting the roots and reading the volume by the displacement of the column of water in the cylinder. In the Plant Nutrition Laboratory at the Londrina State University (UEL), the roots, leaves and stems were analyzed to determine the content of N, P, K, Ca, Mg, Mn, Zn and Fe. The pH and EC of the potting media were also determined once again when the plants were evaluated, following the method proposed by Kämpf et al. (2006).

Statistical analysis

Data were subjected to analysis of variance and the means compared using the Tukey's test at 5% probability.

Conclusion

Potting media composed of sand + coconut fiber and vermiculite + coconut fiber are recommended to promote higher build-up of nutrients and a higher growth rate when growing desert rose in pots.

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